GEOLOGY & GROUNDWATER TECHNICAL REPORT

Anaconda Nevada Moly Project

GROUNDWATER AND GEOLOGY TECHNICAL REPORT

Support Document for the

Draft Environmnetal Impact Statement

Anaconda Nevada Moly Project

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PREFACE

The Anaconda Copper Company of Denver, Colorado, plans to develop an open pit molybdenum mine and flotation mill plant on privately owned land and public land on which the company has located mining claims under the general mining laws, approximately 18 miles north of the town of Tonopah in Nye County, Nevada. In order to supply power to the Anaconda project, Sierra Pacific Power Company of Reno, Nevada, has filed with the U.S. Bureau of Land Management (BLM) an application for a right-of-way to construct and operate a 230kv electric transmission line which would cross 86 miles of public land in the Big Smoky Valley in Nye and Lander Counties. Sierra Pacific's right-of-way application initiated BLM's environmental analysis process and the decision was made to prepare an Environmental Impact Statement (EIS) on the proposed transmission line and the Anaconda mine/mill complex. The EIS is being prepared on a contract basis by Environmental Research & Technology, Inc. (ERT), of Fort Collins, Colorado.

This report was prepared by ERT as a preliminary step in the EIS preparation process. The report provides detailed information on the groundwater and geology of potentially affected areas and discusses the impacts of the proposed project on these resources.

The groundwater and geology report is one of a series of ten technical reports prepared by ERT as background and documentary material for the EIS. Each report presents the results of field and literature studies in the affected environments and results of impact analyses. The technical reports are intended as background documents and information in them is, in many cases, considerably more detailed than will be included in the EIS.

Chapter 1, "Alternatives Including the Proposed Action", can be found in the Draft Environmental Impact Statement which is on file with copies of the technical reports at the following locations: BLM offices in Washington, D.C.; Reno; Battle Mountain; Carson City; Elko; Ely; Las Vegas; and Winnemucca, Nevada. The following public libraries will also receive copies: the Churchill Public Library, Fallon; Clark County Library, Las Vegas; the Elko County Library, Elko; the Esmeralda County Library, Goldfield; the Eureka County Library, Eureka; the Lander County Library, Battle Mountain; the Mineral County Library, Hawthorne; the Nevada State Library, Carson City; the Nye County Library, Tonopah; the Washoe County Library, Reno; and the White Pine County Library, Ely. Draft EISs will also be sent to the University of Nevada Libraries in Reno and Las Vegas.

CONTENTS

	Page
Preface	
List of Tables	
List of Figures	
1. Alternatives Including the Proposed Action	
2. Existing Environment	2- 1
Physiography	2- 1
Regional Overview	2- 1
Big Smoky Valley	2- 1
Mine/Mill Complex	2- 2
Bedrock and Surficial Geology	2- 2
Regional Overview	2- 2
Big Smoky Valley	2- 3
Mine/Mill Complex	2- 4
Seismicity	2- 7
Regional Overview	2- 7
Big Smoky Valley	2- 9
Mine/Mill Complex	2-10
Groundwater Resources	2-13
Regional Overview	2-13
Big Smoky Valley	2-13
Mine/Mill Complex	2-14
3. Environmental Consequences	3- 1
Introduction	3- 1
Assumptions and Analysis Guidelines	3- 1
Effects of the Proposed Action and Alternatives	3- 3
Topography	3- 3
Seismic Stability	3- 3
Groundwater Quality	3- 6
Groundwater Hydrology	3-10
Mineral Resources	3-13
Relationship Between Local Short-Term Use of the Environment and the Enhancement of Long-Term Productivity	3-13

CONTENTS (CONTINUED)

	Page
Topography	3-13
Groundwater Resources	3-13
Mineral Resources	3-14
Irreversible and Irretrievable Commitment of Resources	3-14
Topography	3-14
Groundwater Resources	3-14
Mineral Resources	3-14
4. List of Preparers	4- 1
5. Consultation and Coordination	5- 1
6. Appendices	6- 1
Appendix A - Methodology	6- 1
7. Glossary	7- 1
8. References	8- 1

LIST OF TABLES

Table		Page
2-1	Description of Bedrock Units Exposed in Immediate Site Vicinity	2- 5
2-2	Major Seismic Events in the Project Region	2- 8
2-3	Groundwater Budget for the Big Smoky Valley	2-15
2-4	Inorganic Chemical Water Analyses - Wells RH142 and RH 140	2-17
3-1	Estimated Earthquake Effects at the Mine/Mill Site for the Nevada Moly Project	3- 5
3-2	Projected Chemical Quality of Tailings Liquid	3- 7
3-3	Local/Regional Drawdown Effects of Groundwater Withdrawals	3-12

LIST OF FIGURES

Figure		Page
2-1	Normal Fault	2-11
2-2	Locations of Geologic Faults and Wells RH 140 and RH 142	2-12
3-1	Computer Simulation of Topography Changes at the Mine/Mill Site	3- 4

CHAPTER 1

ALTERNATIVES INCLUDING THE PROPOSED ACTION

(Refer to the Draft Environmental Impact Statement)

CHAPTER 2

EXISTING ENVIRONMENT

PHYSIOGRAPHY

Regional Overview

The project region is situated within the Basin and Range Physiographic Province, which covers approximately 300,000 square miles or 8 percent of the United States (Hunt 1974). This province emcompasses virtually all of the state of Nevada, and portions of Idaho, California, Utah, Arizona, New Mexico and Texas. The project region falls within the Great Basin Division of the Basin and Range Province, a division which makes up about half of the province and includes most of the state of Nevada and portions of contiguous states. The Great Basin is characterized by elongated mountain ranges trending roughly north-south and separating large alluvial basins. The mountain ranges are generally 50 to 75 miles long and 10 to 25 miles wide. The average elevation of the basins is 5,000 to 6,000 feet above sea level; the mountains rise up another 2,000 to 3,000 feet (Hunt 1974; Erwin 1968).

The Great Basin has been subdivided into five areas, based on their physiography (Hunt 1974). The project region is located in the southwest portion of the Central Area, which encompasses much of central and eastern Nevada. The topography in the Central Area (as well as most of the Basin and Range Province) is primarily the result of block faulting and erosion during the Tertiary and Quaternarv Periods (Erwin 1968). The mountain ranges in the southwest part of the central area of the Great Basin were formed by block faulting which began during the Oligocene Epoch (25 to 40 million years ago) (Hunt 1974). The block faulting was accompanied by extensive eruptions of lavas and tuffs which were incorporated into the uplifted blocks which became the mountain ranges. Erosion of these mountains produced the vast deposits of alluvium which fill the basins between the ranges (Hunt 1974).

Big Smoky Valley

The Big Smoky Valley is a 2,926 square mile basin, (Rush and Schroer 1970) trending north-northeast to south-southwest surrounded by several mountain ranges. The major ranges which serve

as the western and eastern boundaries are the Toiyabe and Toquima ranges, which reach elevations in excess of 11,000 feet above sea level or over 5,500 feet above the valley floor. The northern end of the Big Smoky Valley is marked by the Simpson Park Mountains. The southern extent of the valley is delineated by the San Antonio Mountains, Lone Mountain, the Monte Cristo Range and Cedar Mountain. These mountains attain elevations from 7,000 to 9,000 feet above sea level or 1,500 to 3,500 feet above the valley floor. The Big Smoky Valley is steepest near the mountain ranges and becomes nearly flat in the center.

The Big Smoky Valley is divided into two hydrologic areas; the northern part, which is topographically closed, and the southern part (known as the Tonopah Flat) which receives some inflow from the Ione Valley (Rush and Schroer 1970).

The topography of the Big Smoky Valley and the surrounding mountain ranges is the result of block faulting and erosion. A number of faults are present in the area. The alluvium filling the valley was removed from the uplifted moutain ranges and deposited in broad fans to blanket the valley floor. As discussed in a later section of this report, the processes of mountain uplift and erosion are believed to be active in present times.

Mine/Mill Complex

The proposed open pit mine would be located in the steep foothills of the western side of the San Antonio Mountains. The site slopes westward; the slope is steepest at the proposed pit site and becomes more gradual to the west. The Liberty Fault (described in the Seismicity Section) runs north-south and transects the mine/mill complex site. It also delineates the boundary between the consolidated rocks of the San Antonio Mountains to the east and the alluvial deposits of the Big Smoky Valley to the west. The exposed rocks east of the Liberty Fault consist of a complex array of sedimentary rock and extrusive and intrusive igneous rock.

BEDROCK & SURFICIAL GEOLOGY

Regional Overview

The Basin and Range Province is characterized by complex geology; rocks ranging in age from Precambrian to Quaternary are present throughout the province. Folded and faulted sediments, intrusive igneous bodies and volcanic formations are combined in complex patterns.

The geology of the Great Basin is the result of several periods of sediment deposition, interspersed with periods of folding, faulting and igneous intrusive and extrusive activity. During the late Precambrian Era, a geosyncline formed in the southern part of what is now the Great Basin. Over 30,000 feet of sediments accumulated in this subsiding trough (Hunt 1974). Another geosyncline formed during the Paleozoic Era, occupying much of the area presently within the Great Basin. Another 30,000 feet or more of sediments were deposited in this large geosyncline (Hunt 1974). A third geosyncline developed during the early Mesozoic Era, and again great thicknesses of sediments were deposited. During the middle and late Mesozoic, a large batholith formed at the site of the present Sierra Nevada. The emplacement of this batholith was concurrent with folding, thrust faulting and uplifting of the geosynclinal sediments to form mountains. These tectonic activities appear to be the result of compressional forces (Hunt 1974; Clark and Stearn 1968). During the late Mesozoic and early Tertiary time, igneous stocks and laccoliths were intruded into the folded and faulted Paleozoic and Mesozoic sedimentary formations (Hunt 1974). The block faulting which resulted in the present topography began in the Middle Tertiary, and was accompanied by extensive volcanism. The erosion of the block faulted mountain ranges produced the alluvium which fills the intermontane basins (Hunt 1974).

Various theories have been proposed relating the activities described above to plate tectonic theory. Is is evident that the Basin and Range Province has been tectonically active in the recent past and may be undergoing structural deformation at the present time. The crust under the Basin and Range area is exceptionally thin (for continental crust) and the upper mantle appears abnormally inelastic (Gilluly, Waters and Woodford 1967). These findings, combined with the high heat flow (evidenced by the widespread hot springs and other geothermal phenomena) are thought to be related to the recent (Quaternary) Volcanic activity in the area (Garside and Schilling 1979). The blockfaulting which began in the Mid-Tertiary appears to be the result of crustal tension. One theory suggests that the Basin and Range overlies a subcontinental zone of sea floor spreading (Gilluly, Waters and Woodford 1967). In any case, seismic evidence indicates that much of the area is still undergoing structural deformation.

Big Smoky Valley

As part of the Basin and Range Province, the Big Smoky Valley is also characterized by complex geology. The mountain ranges bordering the valley consist of geological formations ranging in age from Precambrian to Quaternary. Four general lithologic units are present throughout the Big Smoky Valley: igneous intrusive, igneous extrusive, carbonate sedimentary and clastic sedimentary (Rush and Schroer 1970, Erwin 1968; Kleinhampl and Ziony 1967). Three categories of unconsolidated deposits cover the valley floor: older alluvium, younger alluvium and playa deposits (Rush and Schroer 1970).

Precambrian siltstones and carbonates are exposed at Lone Mountain, where Precambrain sedimentary rocks are overthrust over Cambrian sedimentary rocks (Erwin 1968). Paleozoic sediments are exposed in most of the mountain ranges surrounding the Big Smoky Valley. Ordovician and Silurian shales and carbonates are exposed in the Toquima Range; Mississippian limestones outcrop in the San Antonio Mountains, and Permian clastics and carbonates are present in the San Antonio and Toiyabe Ranges (Erwin 1968). Mesozoic sediments (primarily sandstone and conglomerate) are exposed in the southern Toiyabe Range. Intrusive igneous bodies of Mesozoic age are found on Lone Mountain, and in the San Antonio and Toquima Ranges (Erwin 1968; Kleinhampl and Ziony 1968). Tertiary sediments and tuffaceous shales (as well as welded and non-welded tuffs, and flows of rhyolitic to basaltic composition) overlie the Paleozoic and Mesozoic formations on the flanks of the mountain ranges. These Paleozoic and Mesozoic formations are also crosscut by Tertiary dikes, sills and plugs (Erwin 1969). Beginning in the Middle Tertiary, normal faulting in the region deformed these various formations and created the present Basin and Range topography (Hunt 1974).

The floor of the Big Smoky Valley is thickly covered by unconsolidated deposits consisting of older alluvium (Miocene and Pleistocene Age) younger alluvium (Pleistocene and Holozene Age) and Pleistocene playa deposits (Rush and Schroer 1970). The composition of the alluvium reflects the composition of the parent rock; thus, the complexity of the geology of the mountain ranges is reflected by the heterogeneity of the alluvium throughout the valley. In general, alluvium derived from extrusive and carbonate rocks has better water-yielding properties than alluvium derived from granite rocks. Granitic alluvium tends to be more finely grained and less permeable than alluvium from carbonate or extrusive formations (Rush and Schroer 1970).

A number of economically important minerals are found in the Big Smoky Valley. Much of the mineralization occurs along the contact between the Paleozoic sedimentary formations and Mesozoic intrusive bodies (Erwin 1968). Minerals found in quantities sufficient for economic recovery include: gold, silver, copper, antimony, lead, zinc, mercury, molybdenum, tungsten and uranium (Baker, Archbold & Stoll 1972). Sand and gravel are also present in large quantities throughout the valley.

Mine/Mill Complex

As noted in the following section, the Liberty Fault transects the mine/mill site and forms the boundary between the valley alluvium and the consolidated rocks of the western slope of the San Antonio Mountains. The geology of the San Antonio Mountains is complex and encompasses an array of lithologic units similar to that found throughout the Big Smoky Valley. The bedrock in the mountain areas is cut by a number of faults. In many cases, these faults form the contacts between outcrops of widely different ages (Kleinhampl and Ziony 1967; Hydrosearch 1975). Table 2-1 lists and describes rock units exposed in the immediate site vicinity.

TABLE 2-1

DESCRIPTION OF BEDROCK UNITS EXPOSED IN IMMEDIATE VICINITY OF ANACONDA MINE/MILL COMPLEX

Age [1]	Description
Miocene to Pleistocene	Older alluvium
Pliocene or Pleistocene	Basalt and andesite
Miocene or Pliocene	Quartz latite inflows and plugs
Miocene or Pliocene	Tuff, tuffaceous shale, and diatomite
Miocene	Welded ash-flow tuffs
Oligocene	Tonopah Formation - welded ash-flow tuff, commonly altered and locally mineralized; tuffaceous sedimentary rocks, and conglomerate
Permian	Pablo Formation - chiefly altered andesite flows and breccias and cherts, minor conglomerate and limestone

Source: Kleinhampl and Ziony 1967.

1/ For explanation of geologic time scale, see table included in glossary.

TABLE 2-2

MAJOR SEISMIC EVENTS IN THE PROJECT REGION

Date	Epicenter Location	Intensity/* Magnitude	Area** (km^2)	Remarks
1845 (?) poss. 1852	Stillwater area (?) poss. Pyramid Lake	greater than 7	unknown	Report based on boyhood recollection of local inhabitant. Shock knocked down people, shook river bank, may have diverted river.
Mar. 26, 1872	Owens Valley, CA	X-XI approx. 8	1,658,000	23 persons killed, 60 injured in Lone Pine; 52 houses (mostly adobe) destroyed. Faulting along east side of Owens Valley extended for more than 70 km; scarps up to 7 m high.
Oct. 2, 1915	Pleasant Valley	X	1,295,000	Faulting for 30-40 km along west face of Sonoma Range, scarps up to 4 m high. All buildings destroyed in Kennedy; chimneys toppled, walls cracked in Winnemucca. Mine tunnels caved in; water tanks fell, roads cracked.
Dec. 20, 1932	Cedar Mountains	X 7.3	1,295,000	Created fissures; zone of rupture 60 km long, 6-14 km wide. Chimneys toppled in Mina and Luning. Boulders dislodged from hillsides. Groundwater flow changed.
Dec. 16, 1954	Fairview Peak and Dixie Valley (2 events 4 min. apart. Fairview Peak approx. 55 km south of Dixie)	X 7.1; 6.8	518,000	These two earthquakes produced two zones of surface rupture; southern (Fairview) zone 50 km long, 10 km wide; northern zone (Dixie) 40 km long, 5 km wide. Highways cracked, groundwater flow changed.

*Roman numeral represents intensity as measured on the Modified Mercalli Intensity Scale. Arabic number represents magnitude as measured on the Richter Scale.

**Area represents the area over which the effects of the earthquake were felt. Figures given are estimates; in many cases (particularly in the 1800s), information on the extent of earthquake effects is very sketchy, relying on the recollections of a few individuals in sparsely populated areas. The low population density also accounts for the limited damage to property.

Sources: NOAA 1973; Ryall 1977.

In order to assess the seismic risk for western Nevada, Ryall (1977) correlated the spatial relationship between epicenters of small earthquakes occurring between 1970 and 1974, and known faults or lineaments. He concluded that:

> "a number of northwest-trending zones in an area of west-central Nevada may have high potential for large earthquakes in the future" (Ryall 1977)

It is impossible to predict <u>when</u> a large seismic event would occur, but some patterns of seismic activity have been postulated. Ryall (1977) believes that there may be a period of increased seismicity for several decades preceding a major earthquake. Also, there is generally a period after a major seismic event during which aftershocks occur; this period may last approximately a century. The recurrence interval of major earthquakes for any given location in Nevada appears to be on the order of several thousands of years (Ryall 1977).

Based on these findings, Ryall has postulated that:

> "a major earthquake will, at some time in the future, occur within a few tens of kilometers of almost any point in the region."

In order to assess seismic risk at a given location, it is important to have an estimate of effective peak ground acceleration (EPA). The EPA is a measure of maximum acceleration of the ground surface (rock) during a seismic event, and should be considered in the design and construction of any structures in seismically active areas. A general map for the conterminous United States (based on the work of Algermissen and Perkins) shows the EPA that would be expected, with 1 in 10 odds, to be exceeded in a 50-year period (or, in other words, the EPA having a 90% probability of <u>not</u> being exceeded in a 50-year period). According to these general maps, the project region would have an expected EPA of 0.20g. It should be noted that ground acceleration varies according to the magnitude of the seismic event, the distance from the epicenter, and the type of geologic formations present at the point of measurement.

<u>Big Smoky Valley</u>

The Big Smoky Valley is flanked for most of its length by mountain ranges formed as a result of block faulting. Systems of faults run along the bases of the mountains trending parallel with the mountains and forming the boundary between the consolidated rocks of the mountains and the alluvial deposits of the valley (Kleinhampl and Ziony 1967; Hydro-Search, Inc. 1975a, Rush and Schroer 1970). These

faults are predominantly normal faults; that is, faults in which vertical displacement occurs as a result of the hanging wall moving downward relative to the footwall (see Figure 2-1). This type of fault has alternatively been referred to as a gravity fault (Billings 1972). In the Basin and Range Prince, normal faults predominate, with the mountain ranges representing the footwall and the basins representing the hanging wall. It should be noted that displacement on normal faults is relative - the hanging wall may have moved down, the footwall may have moved up, or some combination of factors could have occurred.

Besides the mountain front faults described above, there are numerous other faults in the Big Smoky Valley. Some run perpendicular to the mountain front faults, forming complex fault systems; others appear to be isolated along the valley floor (SHB 1978; Rush and Schroer 1970). The great thickness of alluvium undoubtedly obscures some faults which are present on the valley floor.

Professor David B. Slemmons, who has done extensive research on seismicity in the Great Basin, has indicated that at least some of the faults in the Big Smokey Valley are active. Based on air photointerpretation, Slemmons has detected activity along the major fault system on the western side of the upper end of the valley and along a smaller fault near the southern end of the Tonopah fault (SHB 1978).

The epicenter of the Cedar Mountain earthquake of 1932 was located just west of the Big Smoky Valley. Other epicenters of lesser earthquakes are located in and around the Big Smoky Valley. As part of the western portion of the Great Basin, the Big Smoky Valley is included in the Zone 3 risk area.

Mine/Mill Complex

The mine/mill site is bisected by the Liberty Fault, an 8 mile long mountain front fault which separates the consolidated rocks of the west slope of the San Antonio mountains from the alluvium of the Big Smoky Valley (SHB 1978; Rush and Schroer 1970; Kleinhampl and Ziony 1967). The Liberty Fault is inactive.

Figure 2-2 shows the location of the Liberty Fault. The Liberty Fault is a normal fault trending roughly north-south and having a westerly dip of 38 degrees. Offset along this fault may be as much as 3,000 feet (SHB 1978). The rocks near the Liberty Fault show intense fracturing resulting from widespread minor faulting (SHB 1978). Figure 2-2 shows a number of small faults in the site vicinity.

As part of the western portion of the Great Basin, the mine/mill site is in a zone 3 seismic risk area and, as such, could expect major earthquake damage (NOAA 1973). There are a number of historic earthquake epicenters within 50 miles of the site, particularly to the west (Slemmons et al. 1964). The epicenter of the Cedar Mountains earthquake of 1932 (7.3 magnitude) is located approximately 49 miles northwest of the site (SHB 1978).

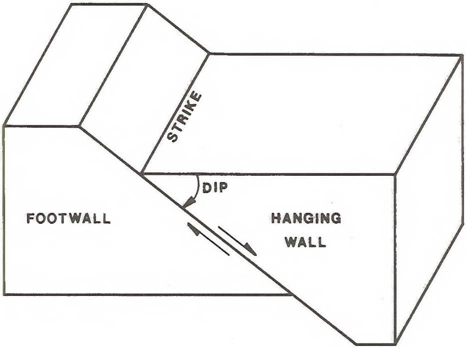


Figure 2-1. A normal fault

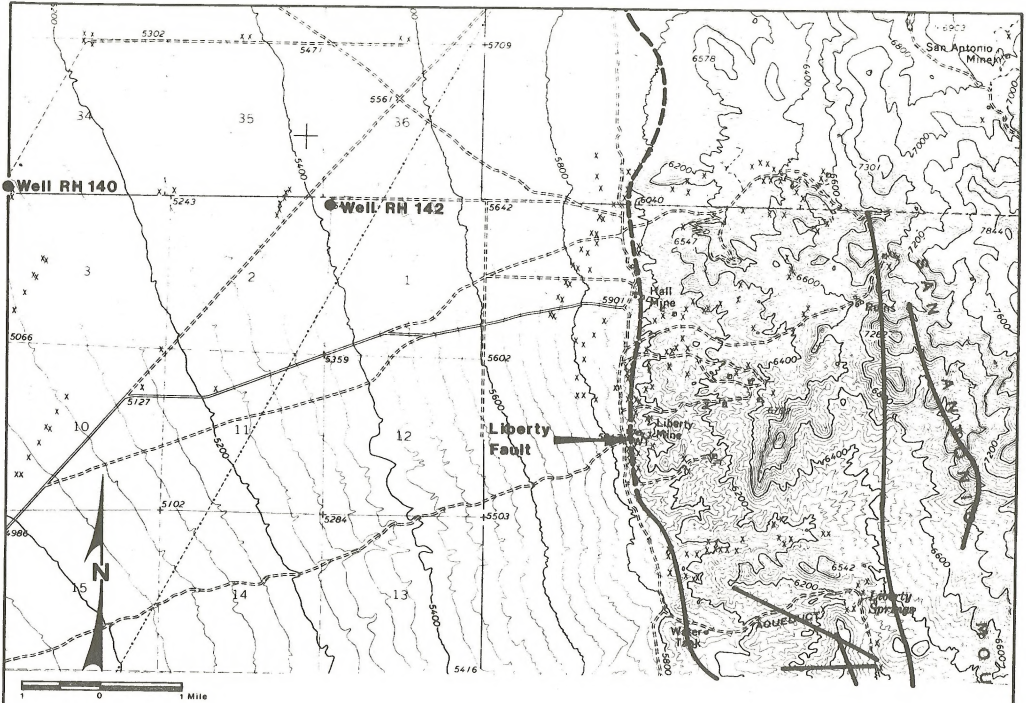


Figure 2-2. Locations of geologic faults and wells RH140 and RH142.
Source: Kleinhampl and Ziony 1967

Fault
(Dashed where inferred)

GROUNDWATER RESOURCES

Regional Overview

The Basin and Range Province is characterized by an arid climate - rainfall is low and surface water is scarce. The Great Basin is in the rain shadow of the Sierra Nevada, and most of its area receives less than ten inches of rain annually (Hunt 1974). Much of the water demand in the region is met by groundwater supplies, which are concentrated in the alluvial deposits of the intermontane basins. Throughout much of the region, the demand for groundwater for domestic use, livestock watering and irrigation, exceeds the supply. Some of the more densely populated areas have experienced problems from overpumping of wells (Hunt 1974).

Most groundwater is obtained from wells into the unconsolidated alluvial aquifers which fill the basins. In some areas, groundwater is obtained from springs along the boundaries between permeable alluvium and less permeable formations, or along faults or other structural discontinuities (Hunt 1974). Both wells and springs can yield large quantities of groundwater. In some areas, salinity can render this water unusable for most purposes (Hunt 1974).

Big Smoky Valley

The Big Smoky Valley encompasses a 2,926 square mile area and is filled with alluvial deposits reaching a maximum thickness of several thousand feet (Rush and Schroer 1970). As noted above, alluvial aquifers are the main source of groundwater in the Basin and Range Province. In the northern part of the Big Smoky Valley, the saturated alluvium holds an estimated 5,000,000 acre-feet of groundwater; in the southern part of the valley (the Tonopah Flat), an estimated 7,000,000 acre-feet of water are stored in the alluvium (Rush and Schroer 1970).

The primary source of recharge for this alluvial aquifer is precipitation. Average annual precipitation in the mountains surrounding the Big Smoky Valley is 20 inches; only 4 to 7 inches of precipitation fall on the valley floor (Rush and Schroer 1970). The 40 streams draining the Toiyabe and Toquima ranges have an aggregate annual flow of approximately 35,000 acre feet (Rush and Schroer 1970).

Outflow of water from the northern part of the Big Smoky Valley is mostly in the form of evapotranspiration by phreatophyte vegetation (plants which send their roots down to the water table) (Rush and Schroer 1970; Hunt 1974). In the Tonopah Flat area, approximately half of the outflow results from evapotranspiration; the other half is thought to be groundwater outflow southward to Clayton Valley (Rush and Schroer 1970). Groundwater flow throughout the Big Smoky Valley is generally north to south (Hydrosearch 1975). Table 2-3 shows the groundwater budget for the Big Smoky Valley.

The alluvial aquifer consists of lenses of sand, gravel, silt and clay derived from the erosion of the surrounding mountains. The thickest deposits occur in the center of the valley, where they reach a thickness of as much as 5,000 feet. One thickly-blanketed area is in the southern area of the Tonopah Flat (Rush and Schroer 1970). Transmissivity varies widely throughout the aquifer, due primarily to the varied grain size of the alluvial deposits. The sands and gravels generally have high transmissivity. Throughout most of the Big Smoky Valley, the transmissivity of the alluvium is thought to be less than 50,000 gallons per day (gpd) per foot, except in the area between Round Mountain and San Antonio Ranch, where it may exceed 100,000 gpd per foot (Rush and Schroer 1970). In areas where playa deposits are present (such as in the southern end of Tonopah Flat), lower transmissivities would be expected due to the fine grain size of these Pleistocene Lake deposits (Rush and Schroer 1970).

A number of springs issue from the mountains surrounding the Big Smoky Valley. Some are small mountain springs, others issue from the alluvium along the west side of the valley floor in the northern part of the valley. The estimated total discharge of springs in the Big Smokey Valley is at least 5,000 acre-feet per year (3,000 gpm) (Rush and Schroer 1970).

Mine/Mill Complex

The western portion of the site is underlain by thick deposits of valley-fill alluvium. Driller's logs for two wells (shown on Figure 2-2) indicate that the thickness of the alluvium increases towards the center of the valley. The thickness of alluvium at well RH 142 is 1270 feet, increasing to 1596 feet at well RH 140 two miles to the west (Hydrosearch 1975b). The elevation of the water table in these wells is 4836.5 feet in well RH 140 and 4832' in well RH 142 (Hydrosearch 1975a). These elevations correspond to depths below the surface of 276 feet and 589 feet for wells RH 140 and 142 respectively. It is estimated that the elevation of the water table is relatively stable, fluctuating only a few feet (Hydrosearch 1975a). The elevation of the water table increases to the east, but the steeper increase in the land surface elevation results in an increasing depth to thewater table (Hydrosearch 1975a). The transmissivity of the alluvial aquifer is estimated to be 52,800 gpd/ft (Hydrosearch 1975b).

TABLE 2-3

GROUNDWATER BUDGET FOR THE BIG SMOKY VALLEY

		Northern Part	Tonopah Flat
Inflow:			
Recharge from precipitation		65,000[a/]	12,000
Subsurface inflow		None	2,000
Total inflow	(1)	65,000	14,000
Outflow:			
Evapotranspiration		64,000	6,000
Subsurface outflow		None	* [b/]
Total outflow	(2)	64,000	6,000
Imbalance: (1) - (2)		1,000	8,000[c/]
Value selected to represent both inflow and outflow:		65,000	14,000

a/ All quantities in acre-feet per year.

b/ No direct estimate made; see footnote below.

c/ May be equal to subsurface outflow to Clayton Valley previously estimated to be about 13,000 acre-feet per year (Rush, F.E. 1968. Water resources appraisal of Clayton Valley - Stonewall Flat area, Nevada and California. Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance Series Report 45).

Source: Rush and Schroer 1970.

An estimated 7 million acre feet (2.3 x 10^{12} gallons) are stored in the upper most 100 feet of saturated alluvium (Hydrosearch 1975b). A pumping test performed on well RH 142 indicated that a constant discharge of 800 gpm could be maintained without difficulty (Hydrosearch 1975b). Specific capacity of the aquifer was rated at 10.67 gpm/ft (Hydrosearch 1975b).

The primary source of recharge for the alluvial aquifer is precipitation falling on the surrounding mountains. Surface and subsurface inflow from the Ione Valley also provides some groundwater recharge to the Big Smoky Valley (Rush and Schroer 1970). Some recharge may reach the valley as subsurface flow from the bedrock of the mountains (Hydrosearch 1975b). The relatively high temperature of the groundwater (29.3-29.5°C) indicates that these two wells (RH 140 and 142) may be tapping a "deeply circulating regional flow system of elevated temperature" (Hydrosearch 1975b). The general direction of groundwater flow in the Tonopah Flat area is from north to south (Rush and Schroer 1970). An estimated 12,500 acre-feet per year flows past the Hall property; well RH 142 intercepts this flow (Hydrosearch 1975b).

The groundwater from wells 140 and 142 is of good quality based on specific electrical conductance of 370-405 microhmos per cm at 24°C and total dissolved solids of approximately 300 mg/1 (Hydrosearch 1975b). The water is classified as soft and of sodium bicarbonate character (Hydrosearch 1975b). The results of inorganic chemical analyses on groundwater from wells RH 140 and 142 are presented in Table 2-4. The water from both wells meets the drinking water standards of the U.S. Department of Health and the Nevada State Department of Health (Hydrosearch 1975b).

TABLE 2-4

INORGANIC CHEMICAL WATER ANALYSES - WELLS RH 142 AND RH 140

	Well 142 3/4/75	Well 140* 8/69
pH	8.0	7.90
Temperature, ^{o}C	29.3	N.A.
TDS (calculated), mg/l (ppm)	295.56	306.40
E.C., mhos/cm @ $25^{o}C$	370	393.1
	All values in mg/l (ppm)	
HCO_3^-	135.1	121.4
$CO_3^=$	neg.	neg.
Cl^-	13.8	12.4
$SO_4^=$	46.4	57.91
F^-	1.03	1.36
NO_3^-	0.89	1.77
$PO_4^=$	N.D.	0.1
NA^+	56.3	49.75
K^+	10.39	9.75
CA^{++}	14.2	20.32
MG^{++}	1.10	2.49
SiO_2	84.4	83.9
As	0.037	0.012
B	0.37	0.36
Fe	0.054	6.1
Mn	0.015	0.055
Cu	0.005	0.165
Al	N.D.	0.5
W	N.D.	0.01
Te	N.D.	0.1
Sb	N.D.	0.1

TABLE 2-5 (continued)

	Well 142-Z 1720, 3/4/75	Well 140* 8/69
Bi	N.D.	0.5
Zn	0.4	0.248
Se	0.005	0.005
Mo	0.025	0.1
Cd	0.01	0.005
Cr	0.015	0.025
Ag	0.01	0.01
Pb	0.002	0.05
Co	N.D.	0.01
Hg	N.D.	0.0012
Ni	N.D.	0.01
Hardness (as $CaCO_3$)	39.98 ppm	60.99 ppm
Taste	Good	
Clarity	clear, some air-minor sand	
Smell	none	

Analysis agency: Water Analysis Laboratory, Desert Research Institute, University of Nevada System, Reno.

Note: N.A., not available; N.D., not determined; neg; negligible.

*Sample taken by J.V.A. Sharp and H.F. Bonham, University of Nevada System. High iron content may be due to preceding inactivity of the well and short duration of pumping prior to sampling.

Source: Hydro-Search 1975b.

CHAPTER 3

ENVIRONMENTAL CONSEQUENCES

INTRODUCTION

Chapter 3 presents a discussion of the environmental consequences of implementing the Proposed Action and alternatives. The discussion of impacts focuses on the mine/mill complex because it is the only project component which would affect topography, geology, groundwater, or mineral resources. Furthermore, since the activities at the mine/mill complex which potentially affect these resources are identical for the Proposed Action and each of the four alternatives receiving detailed analysis in the EIS process, the discussion applies to all alternatives presented in Chapter 1 (see DEIS for description of the alternatives).

ASSUMPTIONS AND ANALYSIS GUIDELINES

The analysis of impacts of the Proposed Action and alternatives was based on several assumptions:

1) It was assumed that the Proposed Action and alternatives would be implemented as described in Chapter 1. Design specifications, facilities, and similar parameters would be as described. Standard operating procedures at the mine/mill complex and committed mitigation measures for the 230kv transmission line would be enforced and adequately implemented. Assumptions 2-7 repeat pertinent descriptions of project components from Chapter 1.

2) The tailings containment area would occupy approximately 1,085 acres of land (includes both dike and pond) at the end of the 20-year production period. Tailings containing fine rock particles separated from the product materials in the flotation process, process water, and reagents to aid the molybdenum extraction process would be distributed from spigots along the downside dike of the pond when the concentrator is in continuous operation. The tailings would be approximately 50 percent solids by weight when piped into the pond; subsequent densification would result in approximately 70 percent solids by weight. The tailings storage area would have an ultimate capacity of 91,500 acre-feet of tailings.

3) The design of the tailings dam (Bechtel 1980) would be approved, prior to construction, by the State of Nevada Division of Water Resources. The dam would be constructed using local competent material obtained from borrow areas within the tailings disposal area and from the mine pit.

Materials used in constructing the tailings embankment would be processed and sized to meet the structural and safety requirements of the dam. The dam was designed to resist earthquake forces (which have a 90 percent likelihood of not being exceeded in a 50-year period) that might be generated by seismic activity at the site. The design of the dam included an internal filter which prevents the hydraulic movement of dam construction materials and an internal drain which prevents the seepage of tailings or other liquid through the dam.

4) Water supply would come from wells located on the property. One 2,000 gallon per minute (gpm), 1,200-foot deep service water well would be provided initially with four similar wells planned for future construction. The service water wells would be spaced approximately 4,000 feet apart. Each well would penetrate the full thckness of the aquifer and would be assumed to operate at an efficiency of 70 percent. The supply would be sized for initial plant start-up requirements of approximately 6,200 gpm which assumes there would be no reclaim water available from the tailings pond. Water would be reclaimed from the tailings pond and recycled in the mill process as soon as feasible, reducing the total water requirement to approximately 3,000 gpm.

5) During the construction period, sanitary wastes would be collected from discharge points within the plant area and piped to septic tanks for treatment and disposal. The design of the septic system would include a seepage control system approved by the State of Nevada. During the operation of the plant, sanitary wastes would be collected and treated in a self-contained, tertiary treatment system.

6) Monitoring instruments would be utilized at the tailings dam and readings of static water levels would be evaluated regularly as a safety measure. The information to be collected would include:

    rainfall runoff into the area; water content and gradation of tailings and the slope of spigotted tailings; piezometric surface within the tailings and the embankment; piezometric surface within the drains; quantity of water flowing out of the drain; accurate record of inflow into impoundment area; amount of recirculated water.

7) A monitoring well would be installed at a strategic location near the tailings dam to assess the potential movement of water which might contain dissolved solids. Samples would be taken and analyzed on a monthly basis.

8) Water quality of the tailings liquid would be as projected from the operation of the Nevada Moly Pilot Plant.

9) Approximately 3,450 acre-feet of tailings material would be discharged each year. Approximately 16.2 acre-feet per day of tailings liquid would be discharged to the tailings pond.

10) Between 20 and 40 acres of the tailings pond would be exposed to standing water at any given time.

11) Estimated long-term seepage rates from the proposed tailings pond are based on available literature and a study conducted for a similar tailings pond. Due to site-specific data limitations, probable physical/chemical characteristics of on-site alluvium are identified on the basis of available literature.

EFFECTS OF THE PROPOSED ACTION AND ALTERNATIVES

Potential effects of the proposed mine/mill complex are related to: topography; seismic stability; groundwater quality; groundwater hydrology; and mineral resources.

Topography

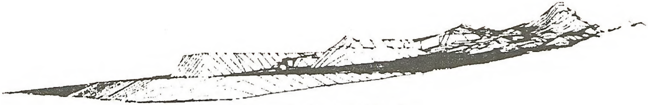
By design, the operation of the mine/mill complex would alter the existing topography of the site. Most of the 769 million metric tons of material removed from the open pit mine would ultimately (1) be deposited in waste disposal areas adjacent to the pit, (2) be used to build the tailings embankment, or (3) would be deposited as tailings behind the embankment. Figure 3-1 compares, through computer simulation techniques, the topography of the mine/mill site before and after implementation of the Proposed Action. As shown, the pit area, now part of the foothills of the San Antonio Mountains would be excavated; areas west of the mountains would be raised and would become level areas above the alluvial valley floor.

The topographic alteration shown in Figure 3-1 would be a direct, significant impact of the Proposed Action. The impact is considered significant because the topographic alteration would be visible from as far as 25 miles to the west and is the primary factor in the conclusion that the mine/mill complex would result in significant impacts to visual resources (see Visual Resources sections of the DEIS or the Visual Resources Technical Report).

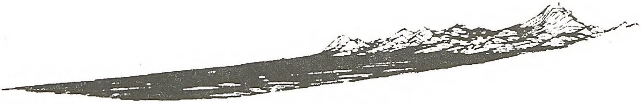
Seismic Stability

As described in Chapter 2, the mine/mill site is located in a region of high seismic risk. This fact necessitated special design considerations for the tailings embankment. Following paragraphs discuss potential earthquake effects on the tailings embankment.

In order to assess the risk of earthquake damage to structures at the mine/mill site, estimates were developed for the effective peak horizontal ground acceleration or EPA which would result from seismic events in the area. Table 3-1 shows the estimated EPA which would have resulted from the five major seismic events (magnitude J7) mentioned in Chapter 2 (Table 2-2). Also shown are projected EPAs which would result from earthquakes along faults considered active in the region. It is estimated that seismic events along these faults could produce EPAs of



2001 As viewed from Southwest at 3 miles



1980 As viewed from Southwest at 3 miles

2001 As viewed from West at 3 miles

1980 As viewed from West at 3 miles

Figure 3-1 Computer Simulation of Topography Changes at the Mine/Mill Site.

as much as 0.26g. This estimate is based on a consolidated rock surface; the estimated EPA for an alluvial site would be somewhat lower (Computer Sciences Corp. 1977).

The proposed tailings embankment would be designed to withstand on-site earthquake effects which have a 90 percent likelihood of not being exceeded in a 50-year period. This design value which corresponds to an EPA of 0.20g, was selected on the basis of a 475-year peak dynamic acceleration contour map derived by Algermissen and Perkins (Bechtel 1980). According to this map, an EPA of 0.20g would have a 90 percent probability of not being exceeded in a 50-year period, or a 96 percent probability of not being exceeded over the project life.

Thus, as Table 3-1 shows, seismic events resulting in greater than the design value of 0.20g EPA at the site are possible. The probability of occurrence of these hypothetical events is unknown, but would be less than 4 percent over the project life. Thus, the probability of occurrence of on-site EPAs greater than the design value is taken to be less than or equal to 4 percent. Should such an event occur, there is a possibility that the tailings embankment could fail, releasing materials stored behind it. However, embankment failure would be possible only if the pond were filled to capacity, or after a 100-year flood. Thus, in order for embankment failure to occur, a major earthquake would have to occur just after the occurrence of a 100-year flood. Since the chances of both events occurring during the entire 20-year project life are estimated at 8 chances in 1,000 (probability of major earthquake in 20 years is 0.04; probability of 100-year flood in 20 years is 0.2), the chances of both occurring simultaneously are extremely small.

TABLE 3-1

ESTIMATED EARTHQUAKE EFFECTS AT THE MINE/MILL SITE
FOR THE NEVADA MOLY PROJECT

Earthquake	Date	Distance from Site (miles)	Magnitude	Estimated EPA[1] at Site (g)[2]
Owens Valley	Mar.26, 1878	75	8.0	0.08
Pleasant Valley	Oct.7, 1915	160	7.6	0.01
Cedar Mountains	Dec.20, 1932	49	7.3	0.08
Fairview Peak	Dec.16, 1954	106	7.1	0.02
Dixie Valley	Dec.16, 1954	98	6.8	0.02
Fault A3 western side of Big Smoky Valley		22	7.5	0.26
Fault B3 southern end of Tonopah Flat		16	6.5	0.22

[1] Effective peak horizontal ground acceleration (EPA) at site estimated from attenuation curves published by Seed et al. (Seed, H.B., R. Murarka, J. Lysmer, I. M. Idriss. 1973. Relations between maximum acceleration, maximum velocity,

distance from source, and local site conditions for moderately strong earthquakes. Report No. 75-17, Earthquake Engineering Reasearch Center, University of California, Berkeley) and Schnabel and Seed (Schnabel, P. J. and H. B. Seed. 1973. Accleration in rock for earthquakes in the western United States. Bulletin of the Seismological Society of America. Volume 63, no.2).

2Gravitational acceleration (g) equals approximately 32 feet/sec.^{2}

3Hypothetical earthquakes on faults near the site which have not generated major historical earthquakes but, based upon geological evidence, may be active.

Source: Sergent, Hauskins and Beckwith Consulting Soil and Foundation Engineers. 1978. Final Report, Phase 1 Hall Molybdenum Project. The Anaconda Company, Nye County, Nevada.

Groundwater Quality

Impacts to groundwater quality could potentially result from (1) seepage of liquid effluents from the sanitary waste treatment facilities, and (2) seepage o tailings liquid from the tailings pond.

As noted in Chapter 1 and repeated under "Assumptions and Analysis Guidelines", the sanitary waste treatment facilities have been designed to control seepage from the system. During plant operation, a self-contained, tertiary treatment system would be utilized for waste treatment, so seepage into the groundwater system would not be possible. During the construction period, a septic system would be utilized. The design includes a seepage control system approved by the State of Nevada which would prevent excessive movement of materials. Therefore, the sanitary waste treatment facilities would not result in impacts to groundwater quality.

Estimation of the potential effects of seepage of tailings liquid from the tailings pond on the underlying groundwater system requires consideration of the following factors:

- chemical quality of the tailings liquid;
- seepage rates from the containment area;
- hydrologic and geochemical processes in the unsaturated zone, and;
- dilution in the saturated zone.

Projected chemical quality of the tailings liquid is shown in Table 3-2. These data are based on chemical analysis of a sample of tailings solution from the Nevada Molybdenum Pilot Plant. At the time of sampling, tailings liquids had been recycled for a period of 4 1/2 days (Anaconda Company, 1979). Of those dissolved constituents analyzed, only sulfate, fluoride, manganese and total dissolved solids concentrations exceed appropriate drinking water standards (see Table 3-2). Additionally, the tailings liquid would contain approximately 25 ppm of methylisobutyl carbinol (MIBC), a froth flotation reagent used in the concentration process. This concentration is well below the known toxic range (greater than 1,000 ppm) for MIBC (Calspan Corporation 1975).

Approximately 16.2 acre-feet per day of tailings liquid would be discharged to the tailings containment area. Approximately 30 percent of the liquid discharged to the pond would be retained by the tailings and thus would not be subject to seepage.

Field permeability testing indicated that the coefficient of permeability of the alluvial materials in the vicinity of the tailings containment area ranges from approximately 1,000 feet per year to greater than 10,000 feet per year (SHB 1978). During the initial stage of tailings disposal, such highly permeable materials would promote rapid infiltration of discharged liquids. Thus, initial seepage rates from the containment area would approach the daily discharge rate (16.2 acre-feet) less the 30 percent retention, or 11.5 acre-feet per day. Continual disposal of tailings would reduce seepage rates. On the basis of studies conducted for a similar tailings pond (W.A. Wahler and Associates 1978), it is estimated that seepage losses over the majority of the project life would be approxmately 10 acre-feet per year per acre. Higher seepage rates would be expected during the first 2 to 3 years of project life with maximum values occurring during the initial stages of operation.

TABLE 3-2

PROJECTED CHEMICAL QUALITY OF TAILINGS LIQUID AT THE NEVADA MOLY PROJECT

Parameter	Estimated Concentration (mg/1)	Drinking Water Standards (mg/1)
Arsenic (As)	.005	.051
Cadmium (Cd)	.001	.011
Chromium (Cr)	.005	.051
Lead (Pb)	.01	.051
Mercury (Hg)	.0005	.0021
Nitrate (No_3)	3	10.1
Silver (Ag)	.001	.051
Fluoride (F)	10.1	1.81
Chloride (Cl)	29.0	250.2
Copper (Cu)	.026	1.2
Iron (Fe)	.03	.32
Manganese (Mn)	.37	.052
Sulfate (SO_4)	521.0	250.2
Zinc (Zn)	.094	5.2
Total Dissolved Solids	1058.0	500.2
Molybdenum (Mo)	.04	---
pH	8.2 units	

140 CFR 1412 - National Interim Primary Drinking Water Regulations
240 CFR 143 - Proposed National Drinking Water Regulations
3Data unavailable
Source: Anaconda Copper Company

As described in Chapter 2, the primary source of recharge to groundwater in the Big Smoky Valley is intermittent streamflow originating in the adjacent ranges that infiltrates into permeable alluvail aprons at the valley margins. Due to the low annual precipitation rates and high potential evaporation and evapotranspiration rates on the valley floor, the moisture content of the unsaturated alluvium at the proposed tailings site may be well below field capacity. Since water infiltrating at the land surface cannot reach the underlying water table until a pre-wetted path has been formed over the entire vertical distance, potentially large quantities of tailings seepage may be permanently stored in the unsaturated zone. Field tests of the movement of water in the unsaturated zone were conducted at the site of a coal-fired generating plant in southern Nevada (Mann 1976). The study site was located on an alluvial surface east of the Newberry Mountains and the materials tested were highly permeable and consisted of fine to coarse sand with 10 to 20 percent gravel. The results of the above study suggested that existing soil moisture content was well below field capacity and that only 12 feet of soil was required to hold 5.25 inches of water introduced at the land surface (Mann 1976).

Test borings conducted at the proposed plant site indicate that moisture content in the upper 100 feet of soil ranges from approximately 11 to 26 percent. Test pits in this same area indicate near surface soil moisture values of approximately 4 to 6 percent (Cooper Clark 1979). Due to its greater relative distance to the prevailing source of local recharge (infiltrating intermittent streamflow originating in the adjacent ranges) soil moisture values below the proposed tailings site may be expected to be somewhat lower than those given above. Assuming an average soil moisture deficit of 2 percent, the vast thickness of unsaturated alluvium present below the tailings area would have a moisture-holding capacity of greater than 19,000 acre-feet. Thus, potentially large quantities of seepage could be held as a pellicular film in the unsaturated zone and not affect the water quality of the underlying aquifer system. Although detailed field-capacity and soil moisture testing would be required to accurately estimate on-site water-holding capacity, available data suggests that large quantities of tailings-pond seepage would be retained in the thick unsaturated zone.

Once a pre-wetted condition has been achieved in the unsaturated zone below the tailings area, tailings liquids would reach, and mix with, the underlying alluvial aquifer. However, prior to reaching the water table, such liquids may be subject to a number of purification processes. Physical-chemical processes that have the potential value of purifying liquids discharged to the subsurface include: precipitation by reaction; hydrolysis and precipitation; precipitation due to oxidation or reduction, and sorption (Runnells 1976). As described previously, the tailings liquid would contain total dissolved solids, fluoride, manganese and sulfate in concentrations above applicable drinking water standards. Travel through the unsaturated zone may significantly reduce dissolved solids concentrations, particularly in areas characterized by great depths to the water table.

One recent study indicated that a soil from Sulfur Springs, New Mexico was capable of removing and retaining large quantities of dis-

solved molybdenum and copper from a synthetic mill water (Runnell 1976). However, the permeable sands and gravels below the proposed tailings site may be relatively inefficient in removing dissolved solids due to the high permeability and low percentage of clay-size particles (Williams 1975). Thus, some attenuation of the total dissolved solids concentrations of tailings seepage would be expected to occur above the water table, however the degree of attenuation is unknown. Similarly, dissolved manganese may be removed from the seepage by the process of oxidation, however it is not possible at this time to predict the degree and net effects of such removal. Detailed studies have been performed on the ability of soils to absorb fluoride in water (Bower and Hatcher 1976). Although alkaline soils (such as the soils at the proposed tailings site) have a relatively low fluoride adsorption capacity, all of the natural soils tested were able to remove large quantities of dissolved fluoride. Of the soils tested, the Hanford sandy loam (pH of 7.2) was characterized by the lowest fluoride adsorption capacity (49 mg per kg of soil). Assuming a conservative fluoride adsorption capacity of 10 mg per kg, the unsaturated soil column beneath the proposed tailings facility would have the capacity to adsorb the fluoride dissolved in greater than 500,000 acre-feet of tailings liquid (with 10.1 mg/l dissolved fluoride). Thus, the process of adsorpton would be expected to significantly reduce the fluoride concentration of tailings seepage. Finally, sulfate is relatively conservative with travel through soils and alluvium; thus the sulfate concentraton of the tailings liquid would not be significantly attentuated in the unsaturated zone.

The last major consideration with respect to tailings pond seepage and possible water quality effects is dilution. As described in Chapter 2, approximately 12,500 acre-feet per year of groundwater flows north to south past the mine/mill property (Hydro-Search, Inc. 1975a). Assuming an average groundwater withdrawal of 3,000 gallons per minute (gpm) over the life of the project, this underflow would be reduced to approximately 7,660 acre-feet per year. Tailings liquid reaching the water table would be diluted and dispersed by this natural groundwater flow system. The nearest existing wells south of the project site are greater than 5 miles downgradient (Rush and Schroer 1970); thus, extensive mixing with the natural flow system would occur between the tailings site and local water supply sources.

Summary of Groundwater Quality Effects

Tailings liquid would contain elevated concentrations of sulfate, fluoride, manganese and total dissolved solids. Over the initial two to three years of operation, large quantities of tailings liquid would be lost to infiltration. However, it is probable that a large portion of this initial seepage would be held as a pellicular film in the thick unsaturated zone, and thus not significantly affect the underlying groundwater system.

Continual tailings disposal would create a low permeability slimes zone at the base of the tailings pond. This zone would permit an estimated seepage rate of 10 acre-feet per year per acre. The total surface area within the tailings pond exposed to standing water at any given time is estimated to be 20 acres; however due to difficulties in accu-

rately predicting the areal extent of free water in the pond, a conservative value of 40 acres is appropriate for impact assessment. Thus, assuming 10 acre-feet per year per acre of seepage over an average surface area of 40 acres, net tailings pond seepage over most of the project life would be approximately 400 acre-feet per year.

An alternate, mass-balance, approach to determination of long-term maximum seepage losses involves the assumption that 50% of the liquid inflow to the pond will be available for recirculation. Using this approach, Anaconda's design contractor (Bechtel 1980) estimated tat 10% of inflow would be lost to seepage (based on 50% recycle, 30% retention in the tailings, and 10% loss to evaporation). It is reasonable to assume that the project proponents will institute any measures required to provide a sufficiently low slimes zone permeability to allow for recirculation. Thus, a reasonable value for maximum long-term seepage loss is 10% of the inflow or approximately 590 acre-feet per year.

Physical and chemical processes in the unsaturated zone may significantly reduce the concentration of dissolved solids in the tailings liquid. Moreover, the large quantities of groundwater flowing beneath the site may effectively dilute tailings liquid reaching the water table. For example, approximately 10 percent (800 acre-feet per year) of the existing groundwater underflow (with an existing dissolved sulfate concentration of approximately 50 mg/l) would be required to mix with 590 acre-feet per year of tailings liquid (521 mg/l sulfate) to produce a downgradient sulfate concentration within drinking water standards (see Appendix A for methodology).

As described above, available data support the conclusion that seepage from the proposed tailings pond would not result in significant impacts to groundwater quality. However, uncertainties are associated with the predicted tailings liquid quality and tailings pond seepage rates. Additionally, data regarding the water-holding capacity and adsorption capacity of onsite alluvial deposits are incomplete or lacking. Thus, monitoring of groundwater quality downgradient of the proposed tailings pond would be required to accurately determine the effects of tailings pond operation and has been included as part of the Proposed Action.

ACC has indicated that a monitoring well would be established downgradient of the tailings pond and that the well would be regularly sampled and tested for key contaminants present in the tailings liquid. In the event of detected adverse effects on groundwater quality, corrective measures, such as dessication or manipulation of the slimes zone to reduce seepage, would be initiated.

Groundwater Hydrology

Impacts to groundwater hydrology are related to potential effects of groundwater pumping during the project life. A specfic question was asked by the wildlife discipline specialist regarding possible effects on Liberty Spring, an important area of wildlife habitat southeast of the mine site. Recharge to the spring is derived from infiltrating precipitation in the San Antonio Mountains. Spring discharge infil-

trates the alluvial apron to the west. The Liberty Spring and its recharge area are located well above the alluvial valley aquifer system. Thus, project-related groundwater withdrawal from the alluvial aquifer would not affect discharge from the spring.

Potential effects on other groundwater users were also analyzed. During the initial stages of project operation, three wells would withdraw approximately 6,200 gallons per minute (gpm) of water from the Big Smoky Valley alluvial aquifer. Continual disposal of tailings would reduce infiltration losses in the tailings pond and permit water recycling to the mill. Groundwater demand over most of the project life is estimated to be approximately 3,000 gpm. Continuous pumping of the proposed supply wells would create cones of depression in the underlying water table. Table 3-3 summarizes the drawdown effects of various operational pumping conditions. This table shows the effects of a single pumping well. Drawdown effects of greater than one well would be additive where the respective cones of depression intersect. That is, two wells located 2,000 feet apart, each operation under conditions shown in Example F (Table 3-3), would result in a maximum drawdown of 30 feet at a point midway between the pumping wells (assuming homogeneous hydrogeologic conditions). Perceptible drawdown effects associated with five wells pumping a combined total of 6,200 gpm for an estimated maximum 3-year period would be confined to a radius of less than 3 miles. No direct effect on other water users in the region would be expected.

The predicted average groundwater withdrawal of 3,000 gpm (4,840 acre-feet per year) represents approximately 39 percent of the natural groundwater flow beneath the ACC property (12,500 acre-feet per year). Although some of this withdrawn groundwater would be returned to the groundwater system via tailings seepage (approximately 25 percent under steady-state operating conditions), most of this quantity would not be returned. Accounting for return via seepage, the average groundwater demand would result in an approximate 34 percent reduction in natural groundwater flow beneath the ACC property.

The concept of "perennial yield" may be applied to the assessment of the effects of proposed groundwater usage on the Tonopah Flat groundwater system. According to Rush and Schroer (1971), the perennial yield of a valley-fill reservoir is defined as the maximum amount of natural discharge that can be salvaged each year over the long term by pumping without bringing about undesired results. As described in Chapter 2 of the geotechnical report, total average annual inflow or recharge to the Tonopah Flat groundwater system is 14,000 acre-feet. Each year, a portion of this quantity (approximately 6,000 acre-feet) is discharged by evapotranspiration under natural conditions. A large portion of this evapotranspiration occurs south of the site between Millers and the southern margin of Tonopah Flat where the depth to groundwater is approximately 10 to 50 feet. The disposition of the remainder of the groundwater discharge from Tonopah Flat (8,000 acre-feet per year) is poorly understood, but is hypothesized to consist of subsurface outflow to Clayton Valley (Rush and Schroer 1971). Rush and Schroer further conclude that this probable subsurface outflow is such that it may not be salvageable by pumping wells. Thus, the preliminary estimate of perennial yield for Tonopah Flat is 6,000 acre-feet, or that quantity lost to evapotranspiration under natural conditions (Rush and Schroer 1971).

TABLE 3-3

LOCAL/REGIONAL DRAWDOWN EFFECTS OF THE NEVADA MOLY PROJECT GROUNDWATER WITHDRAWALS

	Examples					
	A	B	C	D	E	F
Pumping period (days)	100	1,000	10,000	100	1,000	10,000
Pumping rate (gpm)	800	800	800	2,000	2,000	2,000
Aquifer characteristics:						
Transmissivity (gpd/ft)	122,800	122,800	122,800	122,800	122,800	122,800
Storage coefficient[a]	0.12	0.12	0.12	0.12	0.12	0.12
Drawdown[b] (ft) at distance (ft) from well						
10	9.4	11.1	12.8	23.6	27.9	32.1
100	6.0	7.8	9.4	15.0	19.4	23.6
1,000	2.5	4.2	6.0	6.4	10.6	15.0
10,000	0	1.0	2.5	0	2.1	6.4
Radius of cone of influence (mi) where drawdown is zero	1	3	10	1	3	10

[a] Generally, storage coefficient for an unconfined aquifer corresponds to its specific yield; in alluvium aquifers this ranges from 0.10 to 0.15; for calculation purposes a mid-value of 0.12 was chosen.

[b] Does not take into consideration the effects of any boundary conditions.

Source: Hydro-Search, Inc. 1975. Development and testing well R. H. No. 142, Hall property, Tonopah, Nevada. Prepared for the Anaconda Company.

Accounting for return via seepage, the net loss to the groundwater system associated with the mine/mill complex will approximate 4,250 acre-feet per year. Combining this figure with the existing groundwater use in Tonopah Flat (approximately 260 acre-feet per year) results in a total groundwater loss during project operation within the perennial yield value estimated by Rush and Schroer (1971).

Thus, the project-related groundwater withdrawals would not be expected to affect other local water uses and no significant impacts on groundwater hydrology are anticipated. It should be noted, however, that the water withdrawn for the mine/mill operation would otherwise move southward into the southern portion of Tonopah Flat. In this area, a gradual lowering of the water table would occur. The magnitude of the lowering is unknown. The duration of the effect would be approximately 20 years (length of time of project operation); however, the effects would not be felt for possible hundreds of years following project operation (Hydrosearch 1976b).

Mineral Resources

The proposed project would, by design, remove approximately 150 million metric tons of molybdenum and copper ore from the Big Smoky Valley reserves. The ore produced at the mine would help meet the nation's demand for molybdenum. No other significant impacts to mineral resources would occur.

THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The Proposed Action involves a short-term commitment of resources for the development of the mine/mill complex and the transmission line facilities. This section describes the relationship between this short-term use of the relationship between this short-term use of the environment and potential future long-term uses. Short-term is defined as the life span of the mine/mill facility (20 years) plus a ten-year recovery period in which abandonment and recovery efforts would be completed (30 year total). The short term lasts until the year 2011. Long term is defined as the future after the year 2011.

Topography

The short-term use of the project area for construction and operation of the mine/mill complex would permanently alter the topography.

Groundwater Resources

There would be an approximate requirement of 4,840 acre-feet of groundwater annually. This represents an average groundwater demand which would result in an approximate 34 percent reduction in natural groundwater flow beneath the Anaconda Copper Company property. The withdrawal would not affect other local users and no significant impacts

are anticipated. However, projected decreases in groundwater underflow would be long term in the sense that the reduced discharge to the southern Tonopah Flat would not be felt for possibly hundreds of years.

Seepage of approximately 500-590 acre-feet per year of tailings liquid out of the tailings pond would occur, but available data indicate that water quality of the underlying aquifer would not be significantly affected.

Mineral Resources

One hundred-fifty million metric tons of molybdenum and copper ore would be removed from Nye County reserves in the short term. The molybdenum ore porduced at the mine would benefit the nation in the short term by satisfying part of the nation's demand for this resource. It is not certain what effect changing technology and economic conditions would have on production of this resource in the long term if the proposed project were not implemented.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

This section identifies the irreversible and irretrievable commitments of resources resulting from the Proposed Action. The term irreversible is defined as use that is incapable of being reversed. Once something is initiated, it would continue. The term irretrievable means irrecoverable; once something is used it is not replaceable.

Topography

The changes in land forms due to excavation of the open pit mine, creation of the tailings dam, and build-up of the waste disposal areas are irreversible. While reclamation of previous land forms is technically possible, such a massive operation would be economically unfeasible.

Groundwater Resources

Mining, milling, and associated activities would irretrievably consume approximately 4,840 acre-feet of groundwater annually.

Mineral Resources

Approximately 150 million tons of molybdenum ore would be processed. The molybdenum and copper products, once shipped would be irretrievable.

CHAPTER 4

LIST OF PREPARERS

INTRODUCTION

The following individuals had primary responsibility for preparing the technical report. Their education, project responsibilities, qualifications, and experience are summarized below.

ENVIRONMENTAL RESEARCH & TECHNOLOGY, INC.

RICHARD J. DEFIEUX, Geologist/Hydrogeologist

B.A. in Geology; M.A. in Geology, Boston University
Anaconda Nevada Molybdenum Project: Responsible for environmental studies related to geology and groundwater. Senior author of Geotechnical Report.
Experience includes management and performance of geological and hydrological investigations in support of Environmental Impact Statements (EIS) policy studies and solid waste/groundwater contamination studies; preparation of geology components of Federal EIS's for proposed oil shale and gold mining projects.

BARBARA K. BUCKLEY, Geologist

B.S. in Geology, Tufts University
Anaconda Nevada Molybdenum Project: Responsible for compilation and review of available geotechnical data and preparation of baseline descriptions.
Experiences includes participation in multidisciplinary environmental impact studies, feasibility studies related to mine disposal of solid waste, and solid waste permitting investigations.

CHAPTER 5

CONSULTATION AND COORDINATION

Preparation of the Groundwater and Geology Technical Report involved coordination with various ACC geotechnical/engineering personnel (including Mike O'Donnell, John Whyte and Bob Trumbley). BLM staff consulted during the study included Norm Melvin, Loren Brazell, Larry Steward and Dick Jewell (Nevada State Office), Dave Eddy (Tonopah Resource Area Office), and Kelly Madigan, Rod Lentz, Mark O'Brien and Calvin McKinlay (Battle Mountain District Office).

Additionally, portions of this report were based on geotechnical and hydrogeological investigations of the site performed by SHB (1978) and Hydro-Search, Inc. (1975). Preparation of the SHB report involved consultation with Professor David B. Slemmons of the University of Nevada, Reno.

CHAPTER 6

APPENDICES

APPENDIX A - METHODOLOGY

The geotechnical investigation included brief reconnaissance of the proposed mine/mill complex and review of available literature regarding the geology and hydrology of the project area. Additionally, numerous unpublished site-specific geological and engineering reports were reviewed and evaluated. On the basis of the above information, baseline descriptions were prepared for the project region, Big Smoky Valley, and the mine/mill complex.

Evaluation of environmental consequences included investigation into potential effects related to topography, seismic risk, groundwater quality and groundwater hydrology. Estimation of potential groundwater quality effects due to tailings and seepage involved consideration of the following factors:

- chemical quality of the tailings liquid;
- seepage rates from the containment area;
- hydrologic and geochemical processes in the unsaturated zone; and
- dilution of the saturated zone.

Site-specific data regarding the above were supplemented by available published and unpublished reports concerning similar projects or the physical characteristics of similar sites in the project region. Probable effects on the groundwater system were measured against drinking water standards promulgated by the U.S. Environmental Protection Agency.

Calculation of the amount of groundwater underflow needed to dilute the tailings water seepage to produce concentrations equal to or less than water quality standards was completed as follows:

$SC + XC^1 = (S + X)\ Q$ where

S is the maximum seepage rate of 590 acre feet per year;

C is the projected sulfate concentration of the tailings liquid (521 mg/1);

X is the quantity of underflow needed to mix with the seepage;

C^1 is the baseline sulfate concentration (50 mg/1); and

Q is the water quality standard (250 mg/1).

CHAPTER 7

GLOSSARY

adsorption	The attraction of ions or compounds to the surface of a solid.
alluvium	A general term for unconsolidated detrital material deposited during comparatively recent geologic time by a stream or other body of running water as a sediment in the bed of a stream or its floodplain, or as a cone fan at the base of a mountain slope.
batholith	A large igneous intrusive body having an areal extent in excess of 40 sq. mi. and composed predominantly of medium- to coarse-grained rock of granodiorite and quartz monzonite.
block faulting	A type of normal faulting in which the crust is divided into structural or fault blocks of different elevations and orientations.
carbonate (rock)	A sedimentary rock composed of more than 50% by weight of carbonate minerals, for example limestone or dolomite.
clastic (rock)	A consolidated sedimentary rock composed principally of broken fragments derived from preexisting rocks (of any origin).
cone of depression	A depression in the potentiometric surface of a body of groundwater that has the shape of an inverted cone and develops around a well from which water is being withdrawn.
dike	A tabular igneous intrusion that cuts across the planar structures of the surrounding rock.
effective peak ground acceleration (epa)	Horizontal ground movement associated with a seismic event and measured as a function of g (gravity = 32 feet/second/second).

epicenter	That point on the earth's surface which is directly above the focus of an earthquake.
extrusive	Igneous rock that has been ejected onto the surface of the earth. Extrusive rocks include lava flows and detrital material such as volcanic ash.
field capacity (field moisture capacity)	The percentage of water remaining in a soil 2-3 days after having been saturated and after free drainage has practically ceased.
footwall	The underlying side of a fault (see Figure 2-1).
geologic time	See chart at end of glossary.
geosyncline	A downwarping of the earth's crust, either elongate or basin-like, measured in scores of kilometers, which is subsiding as sedimentary and volcanic rocks accumulate to thicknesses in thousands of meters.
gravity fault	Normal fault (see below).
hanging wall	The overlying side of a fault (see Figure 2-1).
intrusive	Igneous rock formed by emplacement of magma in preexisting rock.
laccolith	An igneous intrusive body generally lenslike in form and roughly circular in plan, less than 5 miles in diameter and up to several hundred feet in thickness, with a postulated dike-like feeder.
methylisobutyl carbinol (MIBC)	A frothing agent used in the concentration of molybdenum ore.
normal fault	A fault in which the hanging wall appears to have moved downward relative to the footwall. The angle of the fault is usually 45-90°.
pellicular film	A film (generally of water) more than one or two molecules thick that adheres to the surfaces of soil and rock particles in the zone of aeration.
phreatic surface	Water table.
phreatophyte	A plant that obtains its water from the zone of saturation or through the capillary fringe and is characterized by a deep root system.

playa	A term used in the southwest U.S. for a dried-up, vegetation free, flat-floored area composed of thin strata of fine grained deposits and evaporated salts from preexisting desert lakes.
plug	A vertical, pipelike body of magma that represents the conduit to a former volcanic vent.
recharge	The processes involved in the absorption and addition of water to the zone of saturation. Also, the amount of water added.
sill	A tabular igneous intrusion that parallels the planar structure of the surrounding rock.
specific electrical conductance	A test used to determine the dissolved-solids content of a water sample.
stock	An igneous intrusion that is less than 40 sq. mi. in surface exposure and resembles a batholith except in size.
thrust fault	A fault with a dip of 45° or less in which the hanging wall appears to have moved upward relative to the footwall. Horizontal compression rather than vertical displacement is its characteristic feature.
transmissivity	In an aquifer, the rate of flow of water, in gallons per day, through each vertical strip of the aquifer 1 ft. wide having a height equal to the thickness of the aquifer and under a unit hydraulic gradient.
tuff	A compacted pyroclastic deposit of volcanic ash and dust that may or may not contain up to 50% sediments such as sand or clay.

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GEOLOGIC TIME SCALE

Era	Period	Estimated Ages of Time Boundaries in Millions of Years
Cenozoic (Age of mammals)	Ouaternary (Age of man)	
		2.5-3
	Tertiary	
		65
Mesozoic (Age of reptiles, notably the dinosaurs; first appearance of birds	Cretaceous	
		135
	Jurassic	
		180
	Triassic	
		225
Paleozoic (Invertebrate forms abundant and varied; first appearance of fishes, amphibians, and land plants)	Permian	
		270
	Pennsylvanian	
		310
	Missippian	
		350
	Devonian	
		400
	Silurian	
		440
	Ordovician	
		500
	Cambrian	
		600
Precambrian (Primitive life forms)		Age of the earth 4,600

Epochs of the Tertiary and Quaternary Periods

Period	Epoch	Estimated Ages of Time Boundaries in Millions of Years
Quaternary	Holocene	
	Pleistocene	
		2.5-3
Tertiary	Pliocene	
		11
	Miocene	
		25
	Oligocene	
		40
	Eocene	
		60
	Paleocene	
		65

CHAPTER 8

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